

IMPLEMENTATION OF THE WANG & SHEELEY SOLAR WIND MODEL

V. J. Pizzo

Code R/E/SE

NOAA/Space Environment Center
325 South Broadway
Boulder, CO 80303

phone: (303) 497-6608, fax: (303) 497-3645, e-mail: vpizzo@sec.noaa.gov

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LONG-TERM GOAL

The goal is to make available on a routine basis accurate predictions of the quasi-steady component of the global solar wind outflow. These predictions have immediate utility for space weather applications and are of direct relevance to the space science community in developing its understanding of the propagation of solar disturbances throughout the heliosphere.

SCIENTIFIC OBJECTIVES

The objective is to bring the existing research version of the Wang and Sheeley (1990, 1992) global solar wind model into routine daily use in the NOAA/SEC forecast center and to make the results readily accessible to the broader research and space-environment user community through the internet and other channels. For the first time, the performance of a global solar wind model will be subjected to rigorous verification procedures, which will form the baseline for tracking future improvements in capability. The three-dimensional map of the interplanetary environment provided by the model is currently the best available real-time assessment of the global distribution of solar wind speed and magnetic field polarity. From the model output, more enlightened predictions of geomagnetic activity can be made and observations of propagating interplanetary disturbances and evolving heliospheric structure can be interpreted more meaningfully.

APPROACH

The source surface potential magnetic field model (Hoeksema and Scherrer, 1986) is used to map observed solar surface magnetic fields up to coronal heights. Observations of the line-of-sight magnetic field at the surface of the Sun are obtained from three different solar observatories (Wilcox Solar Observatory, WSO, Mount Wilson Solar Observatory, MWO, and Kitt Peak National Observatory, KPNO). A model calculation is run separately for each data set to span data gaps at any one location and to account for differences in the magnetic response of the various instruments. (The impact of these differences on the predictions are not well known and their evaluation is a secondary goal of the study.)

The solar surface magnetic field distribution must be compiled synoptically because, due to projection effects, the area over which the magnetic field can be measured accurately is limited to a small region about disk center. In the original research mode, input maps were assembled over the course of a solar rotation (approximately 27 days) and only then was a solution executed. In the SEC operational mode, the surface magnetic distribution is updated daily where

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possible and a new map is generated, so that the predictions may account better for changing conditions at the Sun.

The raw model output consists of the distribution of open magnetic field on a spherical "source surface" lying 1.5 solar radii above the surface of the Sun. The relative rate of expansion of the fieldlines from the Sun up to the source surface is determined by subsequent calculation. The expansion factors so derived have been empirically related to the solar wind speed at 1 AU (Wang, 1995), and this relation is the basis for mapping the flow out from the source surface to the vicinity of Earth. The model thus predicts solar wind speed and the interplanetary field polarity, including the location of the heliospheric current sheet. Secondary predictions, such as geomagnetic Ap and high-energy electron fluences, can then be derived from these quantities.

To build statistics for predictive purposes and to provide a measure for successive improvements, the predicted speed and polarity variations at 1 AU are collected and compared against in-situ spacecraft measurements from WIND, IMP 8, and other interplanetary platforms. From these statistics, quality indexes for the original and daily updated versions of the model can be accumulated and used as a reference for judging the merits of further upgrades to the model.

Upgrades now envisioned include splicing into the synoptic map a wider portion of the daily full-disk magnetograph data to maximize the area having the most recent data; use of data from additional observatories to fill residual data gaps; and use of data from the SOHO/MDI instrument to assess the effects of higher-resolution, more uniformly sampled inputs.

WORK COMPLETED

Model codes were obtained from the original researchers and were brought into operational mode on the NOAA/SEC system. Adaptations included streamlining the code, modularizing it, and recasting it into a form compatible with SEC's Rapid Prototyping Center (RPC) effort. In addition, all inputs and outputs of digital and graphical data were automated, as was the archiving process. These steps were taken to assure long-term operational maintainability of the model and to facilitate incorporation of future improvements.

A Web page (<http://solar.sec.noaa.gov/~narge/>) has been created to disseminate daily model results to the SEC forecast staff and to the outside community. Long-term collection of predicted and in-situ measurements for statistical verification has been established and automated. A map of the spiral interplanetary magnetic field and associated speed and density structure near the ecliptic plane is being attached to the Web page, and other graphical improvements will be added in the near future.

This work was done in collaboration with CIRE post-doctoral researcher N. Arge, who was specifically hired for the project.

RESULTS

Preliminary results from the first stage of improvements to the model indicate that daily update of the input data enhances the accuracy of the model output, relative to that of the conventional 27-day input maps used during the research phase of the model development. The magnitude of the improvement remains to be verified over a longer time-period, particularly as the Sun becomes more active and changeable. In addition, there is evidence that the three-day advance predictions

from the model are the most accurate, since the mapping in that case is most consistent with the flow time of the solar wind to 1 AU.

IMPACT/APPLICATION

SEC forecast center staff is incorporating the output of the Wang & Sheeley model in their everyday assessment of the geospace environment. The model development team is working with the forecasters to improve the operational pertinence and ease of use of the graphical displays generated by the model.

With the recent rise in solar activity, researchers need to have a clear picture of the interplanetary environment to interpret properly the propagation of solar events as observed by SOHO and other remote-sensing and in-situ spacecraft. Ready availability of accurate maps of the background solar wind flow state, as provided by the operational version of the Wang & Sheeley model, will play a crucial role in this process. Moreover, it may be anticipated that what is learned in such studies will point the way toward further improvements in the Wang & Sheeley model itself.

TRANSITIONS

SEC forecasters now enjoy daily access to the model results while forming their estimates of the likelihood of geoeffective solar activity.

The research community has also been accessing the Web site, which will be installed in a more prominent location on the SEC home page when the upgrade of that site is complete.

RELATED PROJECTS

The PI is engaged in the following work at SEC related to global solar wind modeling and forecasting :

1. In collaboration with CIRES researcher Dusan Odstrcil, V. J. Pizzo is conducting 3-D time-dependent simulations of the interaction of coronal mass ejections with the background global solar wind structure; and
2. Hildner and V . J. Pizzo are collaborating with Z. Mikic and J. Linker (SAIC, San Diego) in NSF-sponsored 3-D MHD modeling of coronal structures and evolution for space weather applications.

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WEB ADDRESS

<http://solar.sec.noaa.gov/~narge/> Wang & Sheeley model daily Web page.

An example of the Wang & Sheeley Web page is appended below (*use a color printer for best results*). Several types of maps of the interplanetary environment are currently available, as are maps of the past few weeks.

This EPS image does not contain a screen preview.

It will print correctly to a PostScript printer.

File Name : wspane2.ps

Title : Wang-Sheeley Model

Creator : Mozilla (NetScape) HTML->PS

Pages : 1